A Study of Cut Marks on the Orleton Mastodon and the Potential Implications of Anthropogenic Modification

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By

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Abstract

The Orleton Mastodon, of the species *Mammut americanum*, was excavated in 1949 in Madison County, Ohio and initial interpretations of the conspicuous markings on some bone elements was of the opinion that rodents had gnawed on the bones during times of drought when the skeleton was at least partially exposed above the pond it was deposited in. Recent discoveries of butchering sites of mastodons and similar Pleistocene megafauna have prompted the re-evaluation of several mastodon specimens for investigation of cut marks made by Paleo-Indians, as some specimens may have been passed over for consideration as they lacked lithic tools associated with the bones. Scanning electron microscopy (SEM) has gained widespread application in this pursuit, particularly when using casts of the cut marks being evaluated as fine-scale imaging can be achieved without destroying the original fossil material.

The mastodon presented in this study underwent classical macroscopic and examination with a Leica microscope to obtain millimeter-scale surface detail of the markings in question. Comparisons of the marks on the Orleton Mastodon were made with those presented in other studies of known butchered mastodons and with other known processes that abrade, fracture, impact, and cut fossils, so that a possible mode of modification could be determined.

Through careful examination, the Orleton Mastodon has been interpreted to possess no signs of Paleo-Indian modification, but possibly has tooth marks produced

by rodents after the mastodon's death. In addition to these alterations, the consistent orientation of these markings with the long axis of the bones prompts the possible explanation of some type of bone disease.

Acknowledgements

My time at The Ohio State University and, more specifically, within the School of Earth Sciences, has afforded me with a valuable bank of knowledge and skill set to be applied in future academic pursuits. But more than that, I have been immersed in a community of faculty, students, and friends that have enriched my enthusiasm for paleontology and the study of geology as a whole.

I owe my deepest gratitude to Professor Dale Gnidovec without whom this thesis would not be possible. He served as a mentor throughout the entirety of this project, accompanying me on multiple trips to OSU's Museum of Biological Diversity so that I could examine the specimen presented in this thesis. Besides feedback and instruction on how to proceed with my research, he has shared my passion for vertebrate paleontology and his excitement over fossils and field work is contagious. Allowing me to intern at the Orton Museum during the fall semester of 2013, he reaffirmed my conviction that I am in the right field as he has said (on more than one occasion), "I have the best job in the world!"

I would like to extend my thanks to the Ohio Historical Society for their loan of the great beast that is the Orleton Mastodon to the Orton Museum. Appreciation is owed to Dr. Bradley Lepper for contributing his publication on the findings of intestinal contents in the Burning Tree Mastodon, and his engaging presentation on said mastodon at the Columbus Rock and Mineral Society. It provided fuel to the fodder that

had already accumulated concerning the types of questions and implications that can be raised by studying Pleistocene megafauna.

My work with the Leica microscope was thanks in part to Sue Welch and Julie Sheets who generously allowed me access to the equipment, and special thanks is owed to Edwin Buchwalter. His patient guidance and experience with the microscope helped me obtain rich images of the bone markings in question.

Of course, a special mention must be made to the source that started a life-long fascination with fossils and ancient life: *Jurassic Park*. Whether in novel or film form, it has tirelessly served as inspiration and will always remain a personal favorite despite knowledge of its inaccuracies.

Finally, I would like to thank my parents and boyfriend, Billy Eymold, for their love and support with my (sometimes obsessive and dinosaur-oriented) paleontological endeavors.

Table of Contents

Introduction

Mastodons are among the best studied vertebrate fauna of the Pleistocene, owing in part to peoples' fascination with their immense size and curiosity over just how fearsome such an animal must have been in life. Ohio records an appreciable number of proboscidean occurrences, including both *Mammut americanum* (the American mastodon) and *Mammuthus primigenius* (the wooly mammoth), with significantly more instances of mastodons (Hansen, 1992). Approximately 250 proboscidean occurrences have been documented in Ohio, most of these coming from isolated finds of the sturdier elements of the skeleton, including teeth, tusks, and bones (Hansen, 1992). Disarticulation is common as are remains too fragmented to assign to a specific species.

Due to the recenct and, therefore, better preservation of the Pleistocene Ice Age event and extinction of some of the fauna characteristic of this age, the Pleistocene extinctions may have a somewhat overemphasized importance in the fossil record compared to the degree of severity that would have been preserved had it occurred deeper in geologic time (Hansen, 1992). Nevertheless, it has served as a debating ground for causes of the extinction of some of the iconic carnivores and even larger herbivores of this epoch.

While there is no geologic record of cataclysmic events to blame for the extinction of the mastodon population and others like it, paleontologists and archaeologists have turned to the activities of Paleo-Indians and their spread into North and South America as a possible explanation. Overkill hypotheses have gained some popularity as evidence of human butchering of megafauna has turned up. Due to increased predation pressures by their natural predators and eventually increasing human populations, some have speculated that large, slow-breeding herbivores like mastodons simply could not repopulate quickly enough to keep up with increased hunting rates (Hansen, 1992).

However, it is likely that a single cause is not the only explanation for their extinction, and that the mastodons were the victims of a complex series of changes to their environment, so that humans may have only played a minor role in exacerbating the problem (Hansen, 1992). Climatic changes were occurring during the Pleistocene, affecting plant growth and diversity which affected narrowly-niched herbivores and subsequently the animals that preyed upon them (Hansen, 1992).

Goals and Objectives

The purpose of this research project was to analyze the skeleton of the Orleton Mastodon for any peculiar markings that could be evidence of cut marks made by Paleo-Indian weapons, either through predation or butchering practices. Positive evidence of such bone modification could then be correlated with the historical age of the specimen and the approximate timing of the mastodons' extinction. Such correspondence could add to the implications that have been proposed in regard to humans having played a significant role in the decimation of the mastodon population. To start out with, the most basic question that could be asked was, "Does the mastodon show signs of bone modification from unnatural means?" Here, "unnatural" is meant to be understood as a variation to the bone structure caused by anthropogenic processes rather than damage sustained throughout the animal's life, carnivore activity from non-human predators, or from post-mortem processes that led to the specimen's deposition and eventual preservation. With this issue at hand, the following needed to be determined:

1. If markings are present, can they be distinguished as definitive work from Paleo-Indians? Such hand-made marks need to be identifiable and easily distinguished from markings that could have been incurred through disease or injuries during the mastodon's natural life, and the degradation of the bone through time caused by post-burial processes or from damage

received through excavation. Furthermore, if it can be assumed that the specimen is an example of an intentional kill, can the damage to the bones be attributed to humans or some other predator and/or scavenger?

2. Do the means by which this particular mastodon died provide any insight into why the mastodon population perished?

Literature Review

Identifying the underlying causes of the late Pleistocene megafaunal extinctions typically involves studies of early man and their activities in North and South America. Historically, common approaches to bone modification analyses relied solely on macroscopic examination and the observational skills of a professional. But within the last four decades, the availability of scanning electron microscopy (SEM) has gained support in its application of paleontological and archaeological studies (Shipman *et al*., 1984). Preparation techniques for the SEM involve the replications of fossil material via a positive cast typically made from epoxy resin poured into a negative impression of the specimen (Rose, 1983). The use of replicas rather than the original material offers a wide range of benefits from easy transportation, possibility for the documentation of various stages of change for a single specimen, and inspection of small areas of a specimen in the SEM chamber without risking harm to the original with the need to make cross cuts (Rose, 1983). Most importantly, however, it allows for a faithful copy of surficial detail from which fine-scale resolutions of 0.1 to 0.25 μm (magnification values of x1,500 to x2,000) can be obtained (Rose, 1983).

Among some of the large, Pleistocene herbivores, mastodons, mammoths (*Mammuthus*), and Jefferson's ground sloth (*Megalonyx jeffersonii*) have been cited as prey victims to Paleo-Indian butchering (Fisher, 1984 & Redmond *et al*., 2012). Recent studies on a late Pleistocene mastodon from Pleasant Lake, Michigan and a ground sloth from Huron County, Ohio have both yielded tool mark patterns, made apparent by micrographs produced through SEM analysis (Fisher, 1984 & Redmond *et al*., 2012).

In the instance of the Pleasant Lake mastodon study, Shipman *et al*. (1984) addressed the issues of misidentifying cut marks with other mark-making processes by designing an experiment to compare bone samples from the Pleasant Lake mastodon with samples prepared by other known means, in both natural and experimental conditions (Shipman *et al*., 1984). Twenty-nine samples were procured from the mastodon, including replicas created through the methods described by Rose, and genuine fragments sliced from larger pieces of bone (Shipman *et al*., 1984). For comparison, some samples showing unmodified surficial detail were selected by Fisher to serve as a somewhat "blind" test aspect for SEM analysis, and his colleagues, Shipman and Rose, were not informed of their inclusion before the SEM examination (Shipman *et al*., 1984). In addition, eight samples were chosen from the New Hudson mastodon previously concluded by Fisher to exhibit signs of being butchered and excavator's marks that were intentionally placed on the bones during its excavation (Shipman *et al*., 1984).

To broaden the spectrum and authenticity of possible mark-making techniques that could have produced those observed on the Pleasant Lake mastodon, comparative material encompassed bone tools from collections at the Smithsonian Institute, sixty-one samples from a series of earlier butchered carcass experiments (using sheep, cattle, and elephants), experimental duplications of gouge-like disarticulation marks featured on the mastodon bones (produced by wedge-shaped tools of various materials such as chert, red oak, fresh bone, and antlers), and experimentally-derived abraded bones that were exposed to sediments ranging from loess to gravel (Shipman *et al*., 1984).

The distribution of the mastodon fossils as they were unearthed was, according to Fisher, suggestive, but not conclusive of human butchery (Fisher, 1984). Similar to the Orleton Mastodon presented in this thesis, the specimen from Pleasant Lake was discovered in a farm pond during dragline excavation (Fisher, 1984). The initial excavation ceased upon recognition of the animal's tusk and further excavation was continued by the Museum of Paleontology from the University of Michigan (Fisher, 1984). With proper mapping of the bones *in situ*, it was observed that the partial skeleton of the mastodon was composed of a single individual with several fully articulated skeletal units surrounded by individual bone elements with little anatomical correlation with the units nearest to them (Fisher, 1984). Fortunately, favorable depositional conditions allowed the Pleasant Lake mastodon to be buried quickly enough to prevent extensive disarticulation and dispersal of its bones. Without such early burial, decomposition of the soft tissues would allow the bone elements to move independently (Fisher, 1984). Due to their inherent small surface area to volume ratio, mastodons and other proboscideans have a tendency to decay relatively quickly compared to smaller animals, so that complete disarticulation may have occurred before all the body tissues have broken down (Fisher, 1984). The Pleasant Lake mastodon is disarticulated in a manner similar to skeletons at other known sites of Paleo-Indian butchery involving bison (Fisher, 1984). For meat-processing purposes, the mastodon's body could have only been manipulated in a small number of ways to allow dissection of the carcass into manageable units (Fisher, 1984).

The arrangement of the mastodon's skeleton could have been affected by carnivores removing elements from the main kill area, or even by others of its own kind; it has been witnessed in modern elephant populations that living elephants show interest in the bones of a deceased elephant, moving bones around with their trunks and even carrying bones for some distance (Fisher, 1984). These modes of displacement seem to be an unlikely explanation for the primary source of disarticulation in this instance. In particular, for a carnivore to have transported a large bone from a mastodon the size of that discovered from Pleasant Lake, it would require intensive gnawing at the joints for which there is no evidence (Fisher, 1984). Based on the low-energy depositional environment the specimen came from, Fisher ruled out physical causes such as trampling, stream transport, or freeze-thaw cycles as explanations for bone displacement (Fisher, 1984).

Some of the most compelling evidence for human modification of the mastodon carcass came from what Fisher interpreted as disarticulation marks. Among the best examples of these marks, were those made on the conarticular surfaces between the atlas and axis vertebrae (Fisher, 1984). In this location, parallel striations in the bone show a polished surface, produced by an object inserted between the vertebrae and moved in a single event of translation rather than repeated movement (Fisher, 1984). This object, based on the movement necessary to produce the observed cut marks and the length of said cuts, was wedge-shaped, tracing a path with greatest bone deformation at the point of insertion, and lessening in the ventromedial direction (Fisher, 1984). To produce such marks, a tool of at least 5 cm in length was used to apply increasing normal and shear stress along the path of the cut (Fisher, 1984). Typically, a standard convention of differentiating man-made cut marks from gnaw marks relies on examining the topography of the marks in cross-section; a sharp, V-shaped trough is telling of human modification whereas a rounded bottom, or U-shaped, channel indicates gnaw marks (Fisher, 1984). However, strong asymmetry in opposing slopes of the striated cuts and an example of an undercut, yet still attached piece of bone (indicating an acute edge made the mark) are in support of human modification (Fisher, 1984).

The controlled, concentrated assault of the wedge-shaped object in this site and several others (such as the left knee) on the skeleton distinguish it from other gnaw marks made by carnivores or scavengers and strongly supports the conclusion that the Pleasant Lake mastodon was at least butchered, if not killed by humans (Fisher, 1984).

To further confirm this conclusion, conspicuous evidence of burning is present on certain bones. Blackened areas show microstructural alteration that occurs during heating in a range of 440° – 650°C, a temperature range that can be achieved within some campfires after several hours of burning but would often not be sustained for more than several minutes in natural grass fires that the carcass may have been exposed to (Fisher, 1984). It would appear that meat was present on the bones during heating, implying Paleo-Indians were cooking their butchered meat (Fisher, 1984).

Of particular insight from this study's findings was that butchery marks could be positively identified on a prey victim without the direct association of lithic tools during the specimen's excavation. Previous approaches to determining the presence of human alteration to bones often relied on the restrictive stipulation that artifacts needed to be present for confirmation (Fisher, 1984). Placing such a limitation on these studies would have eliminated the Pleasant Lake mastodon and several other specimens like it for consideration. Of course, one kill site is not indicative of human causation for the mastodons' extinction, thus overkill hypotheses must be evaluated on the context of many butchery examples and correlated with empirical data of abundance of both human and prey populations and temporal constraints. In the case of the Pleasant Lake mastodon, other mastodon occurrences were used for comparison and study, for a total of nine sample sites (Fisher, 1984). This is an unusually high frequency of butchery within a limited geographic range in the Great Lakes region (Fisher, 1984). It is also necessary to consider that butchery does not equate to killing of every mastodon found to have anthropogenic modification; it is likely, even probable, that humans were opportunistic in scavenging or taking down animals already weakened by natural causes. To distinguish the likelihood of hunting vs. scavenging, examination is needed of the seasonal timing of the butchered mastodon's death (Fisher, 1984).

Depositional Environment

The Orleton Mastodon was unearthed in 1949 by employees of Mr. W. G. Putnam, manager of Orleton Farms in Madison County, Ohio (Thomas, 1952). While searching for a plugged drain tile on the property in November, workers were probing the ground with iron rods when one of them came upon a large bone (Thomas, 1952). Putnam notified the staff of The Ohio State Museum who identified the specimen as that of *Mammut americanum* (Thomas, 1952). Excavation of the mastodon included the cooperation of members of the museum along with professors from The Ohio State University, Yale University, Western Reserve University, and Amherst College; an eclectic assortment of specialists in subjects of glaciology, ecology, archaeology, and paleontology (Thomas, 1952).

The specimen was recovered from a layer of limy clay, or marl, with the uppermost elements ranging only one foot and four inches to two feet and two inches from the surface (Thomas, 1952). Due to its shallow burial, the crew initially working on digging a trench for the tile line accidentally cut into the upper skull (Thomas, 1952). The layer of marl had a thickness of about 1 foot and extended to a depth of three feet, bounded on its lower surface by a layer of glacial till and on its upper surface by two feet of dark, peaty material (Thomas, 1952). Horizon streaks composed of mollusk and ostracod shells were present in both the peat and marl layers (Thomas, 1952). Based on the differences in taxa of the mollusk populations between the peat and marl layers, Dr.

La Rocque of The Ohio State University determined that very different ecological conditions were preserved during these two depositional events (Thomas, 1952).

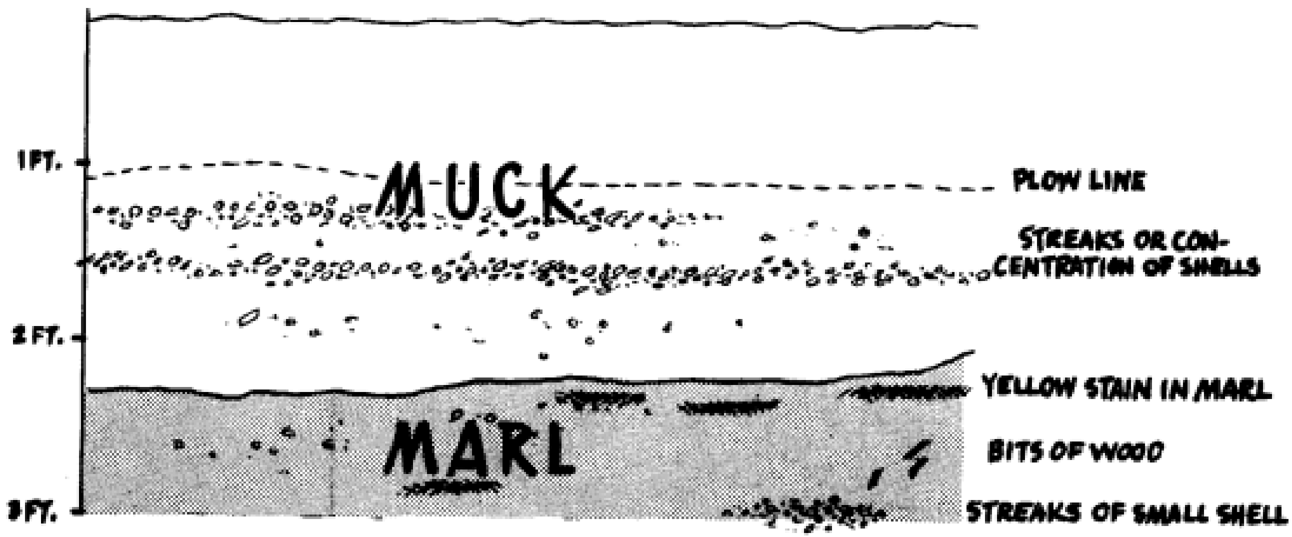


Figure 1: Diagram of the depositional environment from which the Orleton Mastodon was excavated (Thomas, 1952).

The environment in which the mastodon died has been interpreted as a shallow, swampy pond fed by surface water and seepages from nearby moraines, transporting large quantities of silt and lime to the pond (Thomas, 1952). This material eventually precipitated out of solution to form the unconsolidated material at the bottom of the depression (Thomas, 1952). With a supply of sediments being fed into the pond, it eventually filled in, allowing vegetation to occupy the previously uninhabitable area (Thomas, 1952). Decomposing plant growth would later form the upper black layers of peat (Thomas, 1952). Dr. Sears of Yale University, a specialist in fossil pollen, analyzed samples taken from the excavation site to find that pollen of pine, spruce, and fir (recovered from the lower deposits) were all present at the time the mastodon died, providing information to reconstruct the environment as a pond surrounded by coniferous forest (Thomas, 1952). It is likely that during times of drought, parts of the mastodon were exposed in the shallow pond (Thomas, 1952).

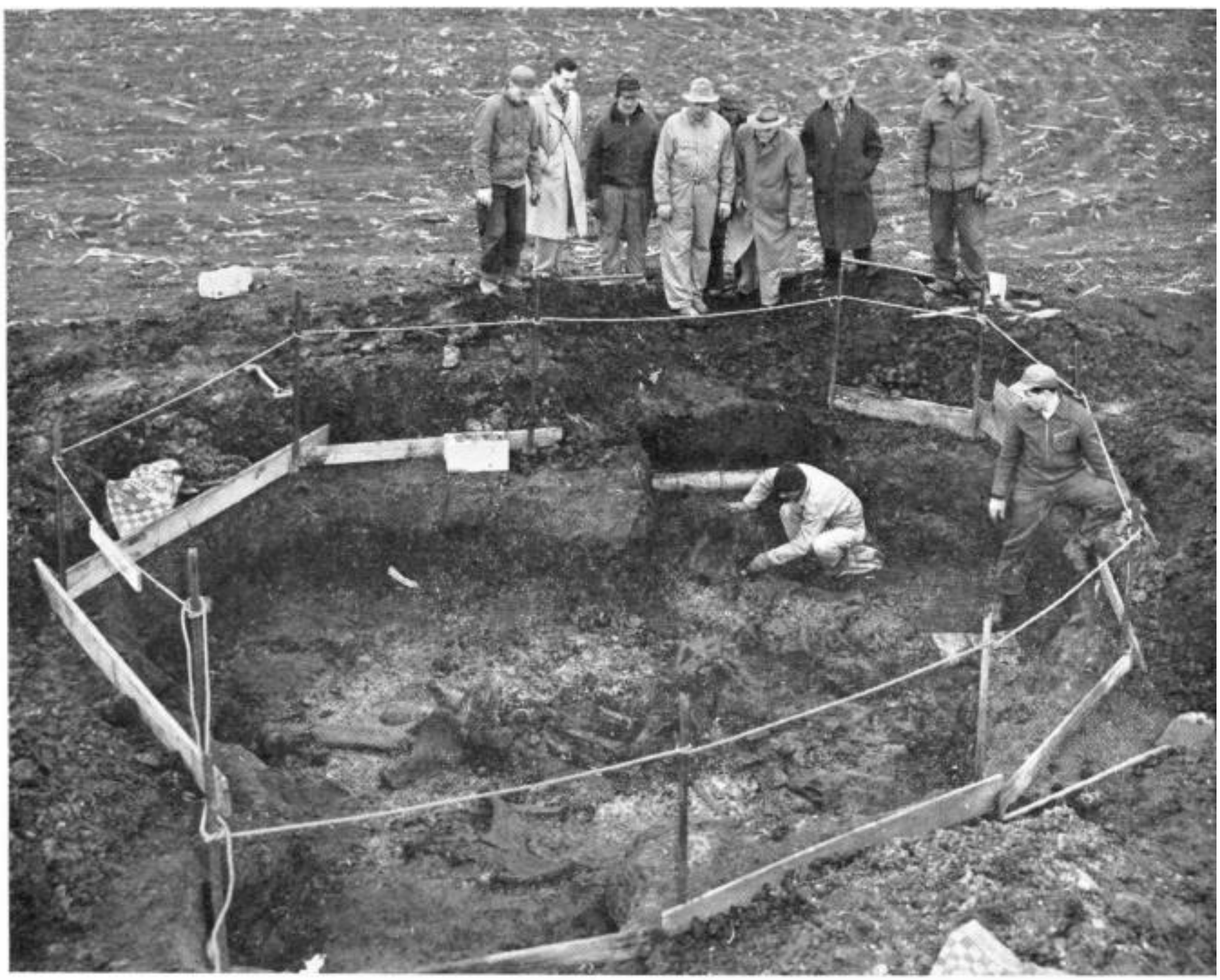


Figure 2: Excavation site for the Orleton Mastodon (Thomas, 1952).

Condition of Specimen

The Orleton Mastodon had suffered considerable damage by the time it was excavated. While some damage was incurred during excavation for the tile line, much of it had already been sustained. Many bones were crushed and broken and the skeleton was greatly disarticulated with elements not anatomically associated with each other, resting against one another (Thomas, 1952). For instance, one tusk was thrust through an aperture in part of the pelvis (Thomas, 1952). Even the most massive bones had evidence of extreme crushing force; the thigh bones were broken squarely across in some places (Thomas, 1952).

The specimen itself has been judged to be a sub-adult at the time of death and large for its age (Thomas, 1952). Data used to place an estimate on its developmental stage came from the detached bone epiphyses and relatively small size of its tusks and teeth (Thomas, 1952). Woody plant material found in the marl just beneath the mastodon was used for radiocarbon dating and produced results of 8,420 ± 400 years (Thomas, 1952). Technically, if this dating is verifiable, the Orleton Mastodon is not of sufficient age to be considered a true fossil as even at the upper limits of this age estimation it would be less than 10,000 years old, marking it as still being “recent” life.

Early Interpretations

In addition to the damage noted in the above section, the bones bear what have been interpreted by Dr. Wood of Amherst College as being gnaw marks made by rodents (Thomas, 1952). This coincides with the interpretation that the skeleton was probably periodically exposed above the surface of the swampy pond.

Wood (1952) identifies the grooves of various sizes in some of the bones as being clear evidence of rodent tooth marks belonging to several species, potentially including beaver, porcupine, woodchuck, muskrat, squirrel, vole, and deer mouse (Wood, 1952). With the possible exception of the beaver and muskrat marks, all of these tooth marks had to be obtained on land while the skeleton was exposed (Wood, 1952).

Due to the high rates of growth in rodent incisors, it is a common habit of rodents to gnaw on hard material to wear them down and create a sharp, chiseled edge of enamel (Wood, 1952). Bone is thus acceptable material for this purpose, and may even be preferential in some instances due to the nutritional value in the mineral resources bones are composed of.

Haynes (1991) uses modern elephants as an analogue for mastodons to infer behavior and study the types of damage incurred to bones through both natural, physical processes and predation from carnivores and humans. In modern African savannah ecosystems, thoroughly utilized elephant carcasses (the extent of use most likely is a reflection of the severity of conditions and competition) will have heavy damage from predators gnawing on bones to crack them open for the greasy, highly nutritious bone marrow (pp. 148-158). Curiously, bone chewing by herbivores was also documented and not an uncommon event. Giraffes and other ungulates will stand among scattered bone assemblages to select bones of no particular type, provided that they are not too large, and will pick them up to chew, reducing the bones to fragments or even fully consuming them in some cases (pp. 148-158). Well-chewed bones will have clear evidence of crushing with a polished, pitted surface and rounded edges (pp. 148-158). This behavior observed in herbivores is likely a response to their body's need for a greater source of calcium and phosphorous (pp. 148-158).

Interestingly, the Orleton Mastodon was found with a three and a half inch chert spear-point located near one of the femurs, just fourteen inches below the Earth's surface (Thomas, 1952). Yet, the weapon was determined to be an early type of man-made tool and thus too old to be contemporaneous with the mastodon (Thomas, 1952). Still, the initial interpretation of the mastodon site suggested that the mastodon, spear-point, and remains of other animals (elements from a deer and a bird of prey) indicate that the pond may have been a frequently visited watering hole, attracting not only thirsty animals, but humans in search of game (Thomas, 1952).

Methods

Macroscopic Examination

To begin with, I had to collect data by removing the specimen's individual components from a total of twenty-four boxes stored at Ohio State's Museum of Biological Diversity. This step in the research process was the most laborious and time-consuming, but at its conclusion, yielded a list of bone elements with what I initially labeled as "suspicious markings." The criterion for suspicious markings in this early stage of the process was based on any signs of damage in the form of cuts noticeably disrupting the natural topography of the bone, particularly any precise incisions or puncture marks with the basic concept in mind to distinguish the mark makers of V-shaped and U-shaped cuts. Bones were especially examined at areas where jointed surfaces would have occurred had the skeleton been articulated as these areas may have shown patterns comparative to those produced by a wedge-shaped object like that mentioned in the study of the Pleasant Lake Mastodon.

During this initial examination, the condition of the bones was noted to show signs of a preparator's hand in that some bones had dried glue along fractures and a few elements were artificially articulated with one another through means of a thin, metal rod. The bones were considerably yellowed and even darkened in some examples, and many elements were broken so that inner cancellous bone was exposed.

At the end of this stage, an assortment of bone elements (mostly fragments, but a few relatively complete individuals) was chosen for further analysis. These elements consisted primarily of rib fragments along with vertebra fragments, a portion of the humerus, and a scapula base.

Suspicious Markings on Mastodon Skeleton	
Element	**Box Number**
femur head, humerus (?) head, vertebra fragments,	3
misc. small fragments	
vertebra fragments, ends of long bones	5
scapula base, half of humerus, misc. small fragments	6
vertebra fragments, rib fragments	18
scapula fragments, vertebra fragments	21
rib fragments	22

Table 1: List of bone elements selected for analysis with the Leica microscope. Note that the element description includes all types of bones that can be found in the corresponding numbered box, not necessarily the elements chosen for study.

Leica Microscopy Imaging

Preferably, scanning electron microscopy would have been incorporated into the analysis of the Orleton Mastodon in order to obtain fine-scale images of the markings in question and have a comparable method set to the standards used in the investigation by Shipman *et al*. (1984) Regrettably, this was not feasible as the available SEM would have required the destruction of the mastodon material in order to prepare usable sample sizes. Destruction of this specimen was neither permitted nor desired and time constraints eliminated the preferable procedure of making casts for analysis. Thus, other means were needed to obtain high quality images of the marks in question.

This led to the use of the Leica microscope which allowed even the largest bone elements to be analyzed. Cut marks could be quantifiably measured for length and width and qualitatively through the acquirement of photomicrographs with magnification capturing fine surficial detail of the bone and the sediments filling in some of the marks. Special attetntion went to some of the origination and end points of the marks to document their shape and depth as this provided information on the characteristics of the mark maker.

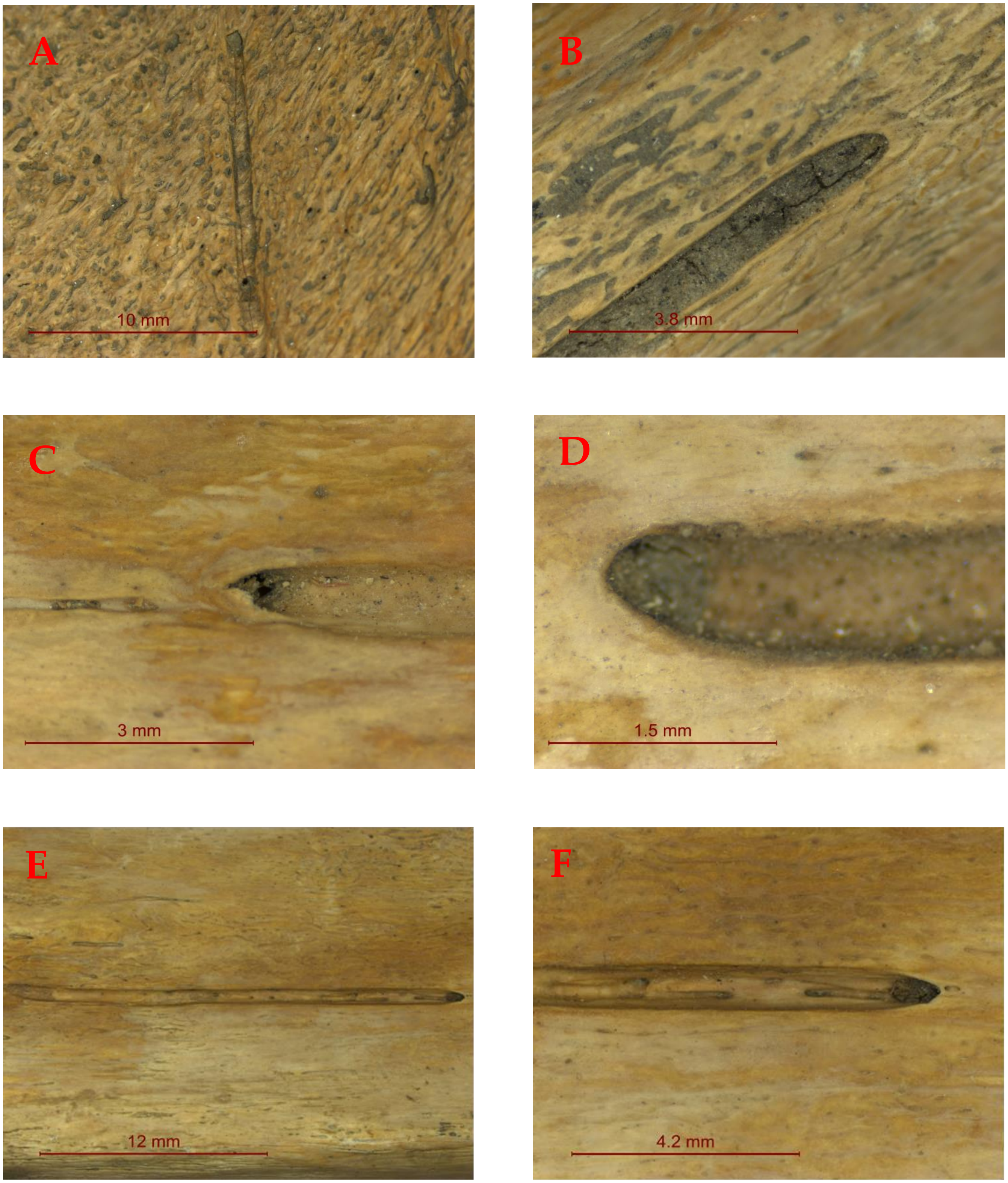
Results

The Leica photomicrographs provided high quality images of the cut marks that could be compared to the images and descriptions offered in the studies of Shipman *et al.* (1984) and Haynes (1991). These images offer fine detail of surface abnormalities from slight gradations in color, cortical and cancellous bone textures, and even fine to very fine grains of dark gray sediment (of what appears to be sandstone) that filled in the grooves of some of the cuts.

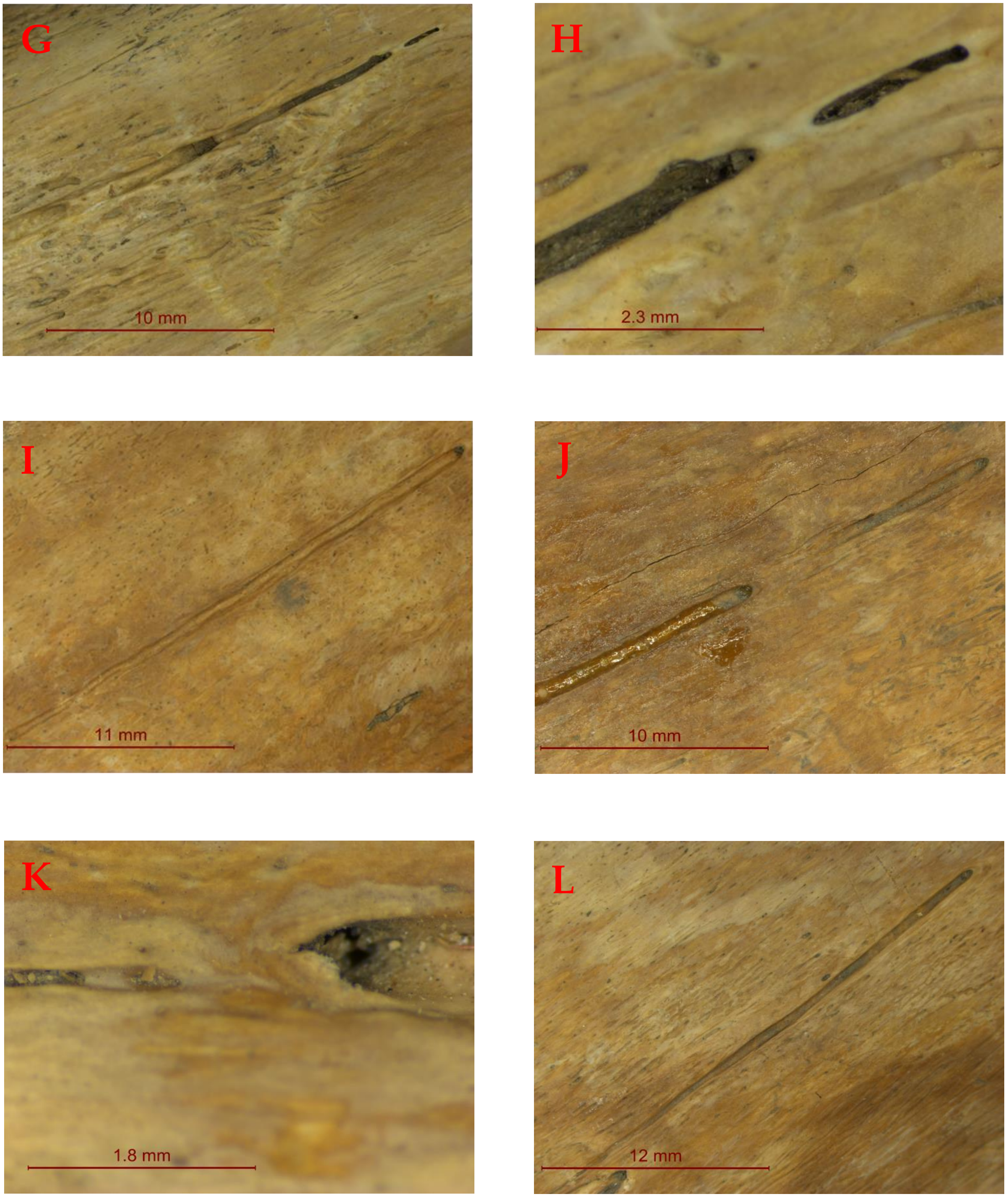
While cut marks were not consistent in sizes, widths typically averaged around 1.0 mm with lengths being more variable and ranging anywhere from as little as 2 mm to more than 30 mm. During the macroscopic examination, these cuts appeared to be fairly clean and straight-edged, and for many this is the case when viewed at a microscopic level. However, some (see photomicrographs A, G, and N in Figure 4 for reference) show slight irregularities in the smoothness of the edges, with slight curves and bumps that may be insignificant, but nevertheless raise the question of how a tool (if it was a man-made implement) was applied with such inconsistency.

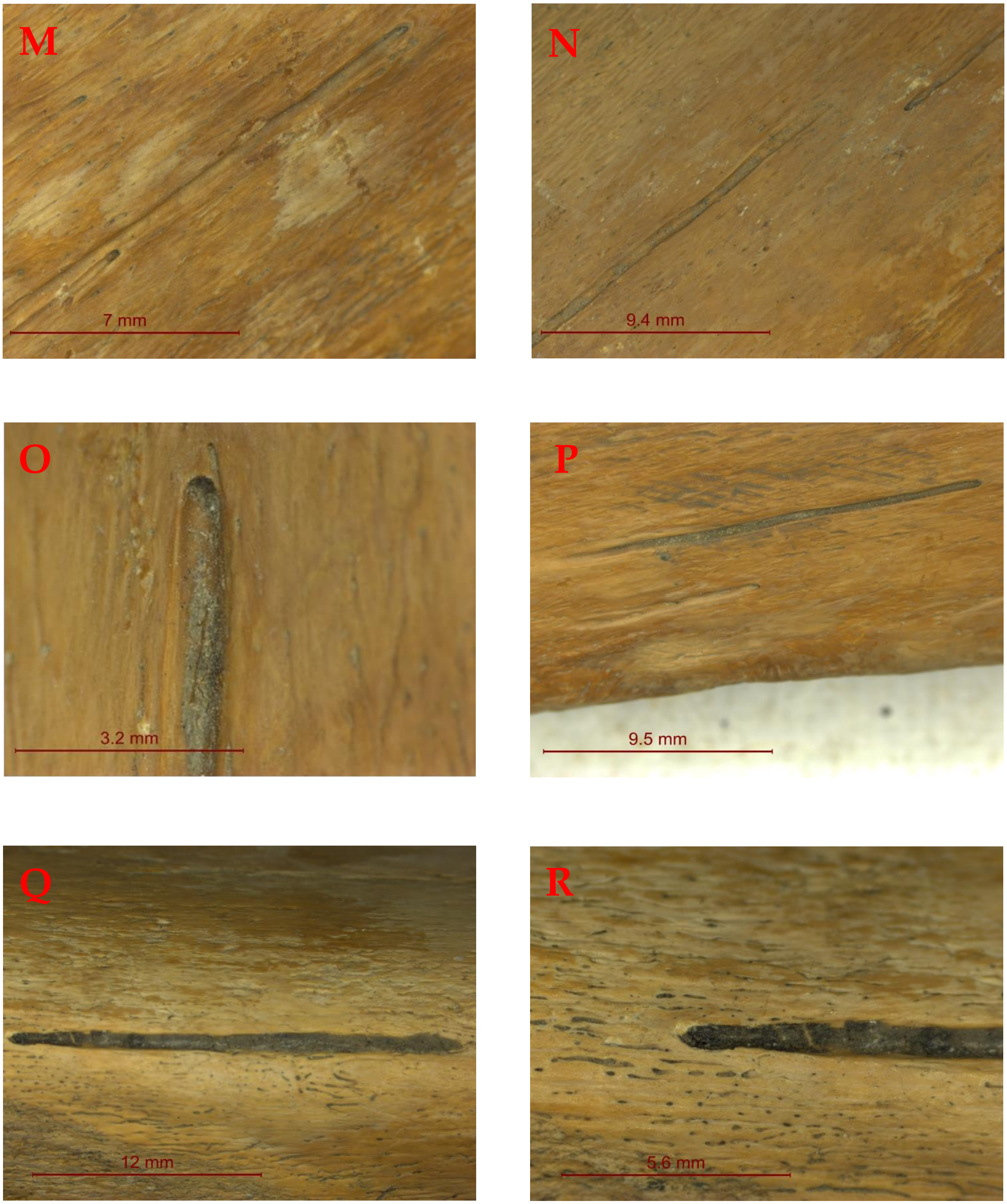
Further variations in marks included the end points of each cut, showing differences in shape and the degree of penetration into the bone. Some endpoints had a U-shaped roundness (see photomicrographs B, D, and O in Figure 4 for clear examples) while a minor portion of the marks displayed sharper, V-shaped incisions (see photomicrographs K and X in Figure 4). In addition to these differences in endpoints, some showed a gradual change in depth proceeding along the length of the cut with a few gently tapering out into compact, cortical bone.

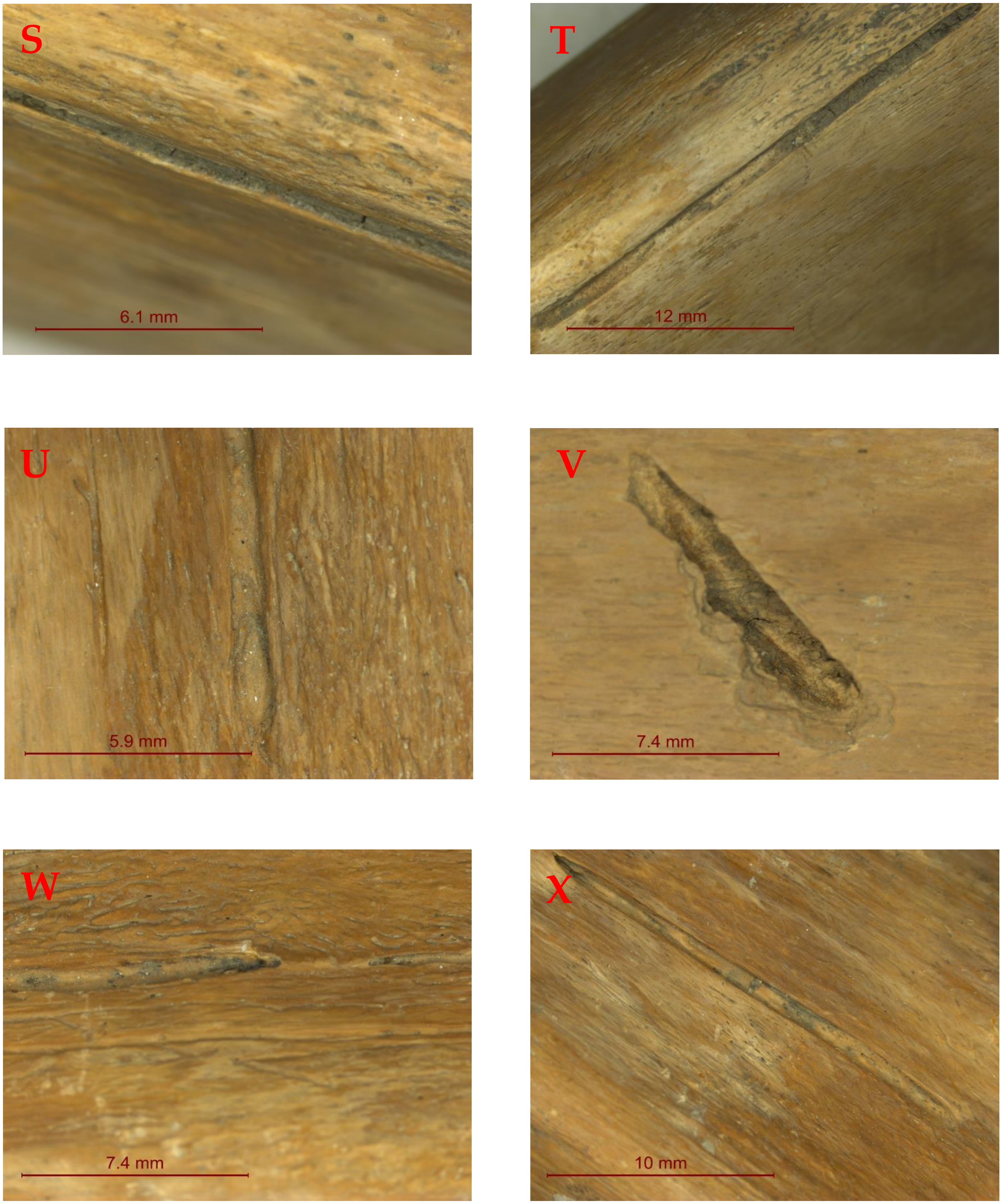
From a topographic viewpoint, observation concluded that neither side of any of the cuts appeared to have a steeper slope than the other – a noticeable characteristic of marks made by trampling (Haynes, 1991).



A
10 mm
B
3.8 mm
C
3 mm
D
1.5 mm
E
12 mm
F
4.2 mm


G
10 mm
H
2.3 mm
I
11 mm
J
10 mm
K
1.8 mm
L
12 mm


M
7 mm
N
9.4 mm
O
3.2 mm
P
9.5 mm
Q
12 mm
R
5.6 mm


S
6.1 mm
T
12 mm
U
5.9 mm
V
7.4 mm
W
7.4 mm
X
10 mm

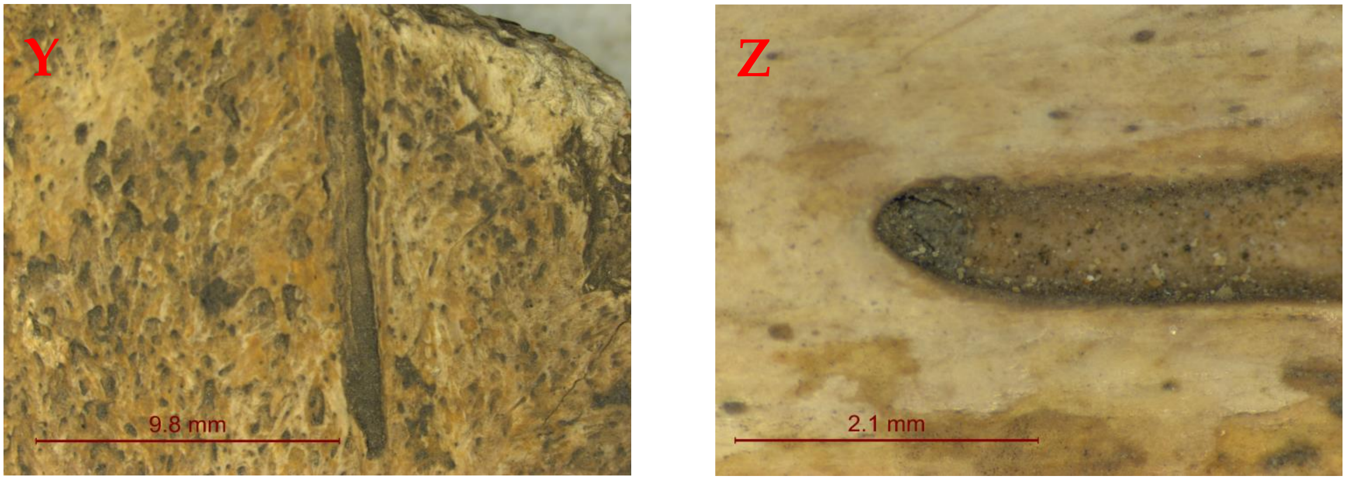


Figure 4: Photomicrographs acquired from the Leica microscope.

Discussion

Clearly, the Orleton Mastodon possesses signs of bone modification, but as to what caused these marks is in question. While this study was undertaken with the hopes of finding evidence of anthropogenic modification, this does not appear to be the case.

Of some curiosity is that all of the markings presented in Figure 4 (with the exception of photomicrograph V) are oriented with the long axis of the bone, and most are on a more flattened portion of the bone (particularly on the rib fragments). While these marks run in the same direction, there are few instances of parallel striations, much less, sets of parallel striations of comparable length. Based on these observations, it seems unlikely that these cuts were created in the event of butchering which would typically produce some overlapping cuts, particularly at jointed surfaces. Furthermore, the concept of cutting along the long axis of the bone during meat processing would seem inefficient. The appearance of V-shaped troughs in the cuts (meaning a human-made tool was applied) also does not seem to be apparent in these bone samples.

In addition to the cut marks themselves, the disarticulated state in which the Orleton Mastodon was found is not consistent with bone assemblages of other known mastodon butchering sites, even though the Orleton Mastodon was deposited in a similar low-energy environment like the Pleasant Lake Mastodon.

If Paleo-Indian activity can be eliminated as a possible producer of these marks, then other options must also be identified and examined for consistency with the data. It is important to also differentiate which marks were produced through the excavation of the skeleton so that confusion does not arise during interpretation. Photomicrograph V of Figure 4 and Figure 5 depicts anomalous markings atypical of those in the rest of the selected samples. I propose that these marks are evidence of damage that occurred during the excavation process as such markings are few if not wholly absent from the rest of skeleton.

Figure 5: Photomicrograph of anomalous impact mark on bone. Note the parallel striations that the mark seems to be superimposed on top of.

Photomicrograph V indicates a gouge-like mark, leaving ragged bone around the edges of the cut in addition to some fracturing in the compacted bone around it. The size of the mark indicates a small tool, but considerable force was applied to produce a mark of such depth. Figure 5 appears to show damage caused by some type of strong, impacting force.

While the marks are much too small to be that of a large carnivore, Dr. Wood's early interpretation of the markings being the results of various species of rodents gnawing on the bones to wear down their incisors is worth revisiting. Yet, what is dissuasive of this explanation is the lack of parallel grooves on the bone. The only instances of this occurrence appear in Figure 6 and Figure 5 may very well be another example of this, however the impact mark superimposed on top of what appears to be two parallel cut marks of comparable length makes positive identification of gnaw marks difficult.

Figure 6: Photomicrograph of possible gnaw marks made by rodents.

Figure 6 is rather compelling evidence in support of gnaw marks, with deeper, rounded puncture-like origination points tapering off gradually as though less force was applied towards the end of the drag lines. Note too, that these marks are not oriented with the long axis of the bone – a rare occurrence compared to the other markings in this study. While these marks maintain an equal distance between one another and appear to start at parallel points to one another, one cut mark is oddly almost double the length of its companion, making it difficult to identify this as gnaw marks. Furthermore, Wood notes that one example of the marks he identified as being that made by rodents was two millimeters in diameter; such a size in the marks analyzed was not found during this study.

While the possibility cannot be ruled out of at least some of the markings analyzed in this study representing gnaw marks made by rodents, other explanations are still plausible. Bone pathologies may have been responsible for the young Orleton Mastodon's death, either being fatal or weakening it to a point that the disease coupled with environmental pressures, such as changing climate, may have been too much. Tuberculosis has been cited as fairly widespread among the mastodon population, with 52% of individual *Mammut americanum* possessing articular lesions from the disease (Rothschild & Laub, 2006). Studies have shown that those affected show no pattern in size or age, making the disease indiscriminatory in that regard (Rothschild & Laub, 2006). This hyperdisease has been proposed as a possible reason for the extinction of many late Pleistocene megafauna species, and evidence of it is often found on the feet and the ribs (although other pulmonary infections could be responsible for abscess cavities and other damages) (Rothschild & Laub, 2006).

While I do not suggest that the markings observed on the Orleton Mastodon match the tuberculosis damage presented in the studies of Rothschild and Laub, it would be worthwhile to consider other bone disease or infection that may have afflicted mastodons. Most puzzling about this specimen is that the markings are all oriented with the long axis of the bones. It would be unlikely that rodents gnawing on these bones would be conscious of this consistency and due to the great disarticulation and incorrect anatomical order of the mastodon when it was excavated, it seems that the markings probably were not incurred by depositional processes.

Conclusion

The Orleton Mastodon, while being an interesting specimen and offering much for interpretation, has been determined through this study not to possess evidence of Paleo-Indian modification. Due to this, it does not offer much in the context of butchering practices nor their frequency. While predation seems not to have been the cause of the mastodon’s demise, tooth marks do appear to be present. Wood’s (1952) initial assessment cannot be ruled out; some of the damage to the skeleton may have occurred during times of exposure when parts of the mastodon were above the surface of the pond and accessible to rodents looking for material to gnaw on. However, based on consistency of the orientation of the marks, and the frequency with which many other mastodon specimens have been cited to have diseases, a bone pathology or infection may have played a role in the young mastodon’s death.

Recommendations for Future Work

The Orleton Mastodon's interpretation could benefit from SEM analysis and with the use of epoxy resin casts, cross section views of the cuts would allow clearer interpretation of the process acting to produce the marks and make a more definitive case against human butchery in this instance. Topographical views are only so reliable in making this verification.

Furthermore, I am somewhat hesitant to accept the initial radiocarbon dating of this specimen and believe it would be worth testing again for improved accuracy. Based on the woody material found directly beneath it, the Orleton Mastodon, at the upper limits of its age estimation, would only be approximately 8,820 years old, an age significantly younger than most measured in other mastodon literature. It may be that this individual was simply a straggling survivor of the last of the mastodon population, but it is much more likely that some error was made in the carbon-14 dating of the woody material excavated with the mastodon, even to the extent that an error was made in the determination that the plant material was actually contemporaneous. Since a Paleo-Indian spear-point was found a mere five inches above the lower end of one of the mastodon femurs, yet concluded by Thomas (1952) to be of too great of age to have been used on the mastodon, it seems plausible that the plant material used for dating may have been displaced through sediment reworking as well. Perhaps one of the most promising sources to look for when excavating mastodons and other fauna akin to it is the presence of gut contents from the animal's last meal. Studies on the Burning Tree Mastodon involved radiocarbon analysis of intestinal content composed of nonconiferous twigs and other organic matter, yielding ages that were more consistent with one another (and therefore assumed to be more accurate) than the mastodon's own bone collagen that produced younger ages (Lepper *et al.*, 1991). While the Orleton Mastodon has been determined not to show evidence of Paleo-Indian modification, it is still necessary to have the most accurate boundaries possible for the existence of mastodons in order to place an accurate time on their extinction and correlate other environmental conditions and the degree of human interference with the timing of this event.

Future research and development of methods for dating the seasonal time of death for mastodons and other large prey animals are needed to make a valid argument for or against the hunting of megafauna by early man. Fisher (1984) noted the difficulty of interpreting the difference between intentional hunting and opportunistic killing or scavenging, even when the skeleton shows clear signs of butchering. Further development and application of his method to measure the dark and light banding patterns of variable thicknesses preserved in the dentine of mastodon tusks are merited (Fisher, 1984). This method uses the rate of tusk growth observed in these depositional patterns as a record of the environmental conditions throughout the animal's life, thereby showing annual cycles, or seasons (Fisher, 1984). The dentine forming at the time of the mastodon's death, preserved in the pulp cavity, has been interpreted by Fisher (1984) to record the season in which the creature died, and similar patterns can be found in the molar teeth to compare with for accuracy (Fisher, 1984). By determination of the seasonal timing of death, a distribution pattern for the mastodon population can be formed, and if butchered and non-butchered mastodons are found to have strongly segregated times of death, this would strongly support the activity of hunting (Fisher, 1984). Lastly, further research could develop an understanding of the full range of pathologies to which mastodons were susceptible and to identify the most common pathologies among their population.

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